

*Progress Report*

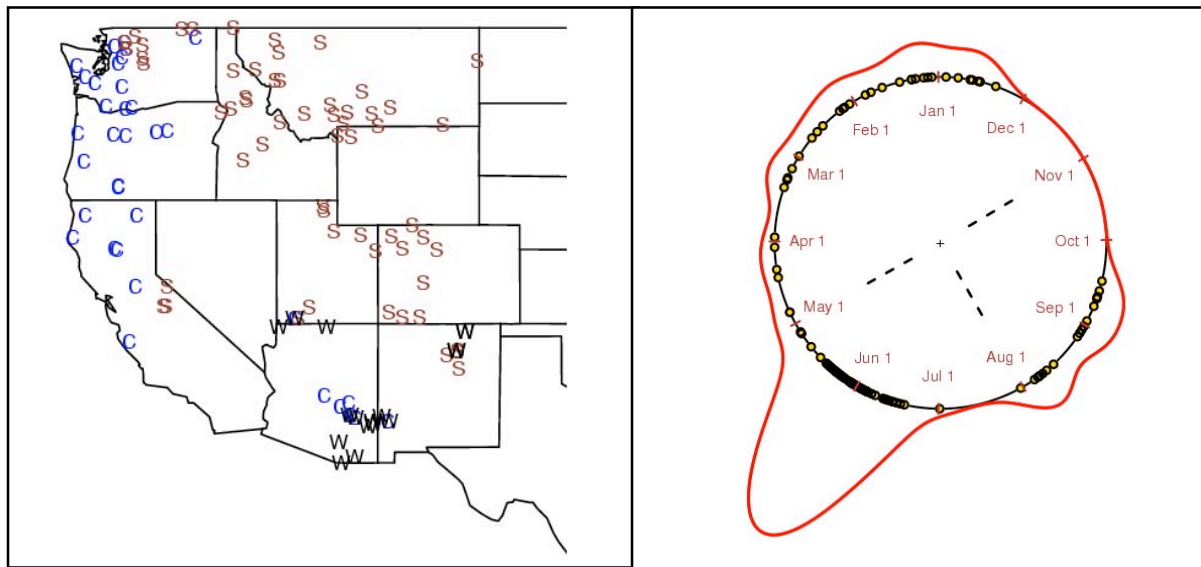
**Variability of Warm season floods in the southwest United States:  
Diagnosis, Impacts, and Applications for Water and  
Adaptive Environmental Management**

*Accomplishments for Oct 1, 2004-Sep 30, 2005*

In the Grand Canyon region, hydroclimatic variability in the warm season is a key determinant of the floods on Paria River, and consequently control the sediment input (volume and timing) into the Grand Canyon. Following the 1963 closure of Glen Canyon Dam, sediment from Paria River and other smaller tributaries within the Canyon are primary sources of sediment for potential ecosystems recovery and maintenance under the aegis of the Glen Canyon Dam Adaptive Management Program.

During the 10/2004-9/2005 project period, two aspects of the southwestern precipitation and floods and connections to water and environmental decision-making were investigated:

1. *Diagnosis framework to understand the seasonality of western US floods* (defined as 3-day peak flows on comprehensive set of nearly 100 streamgauges for the 1940-2002 period). A nonparametric statistical methodology was developed to classify the seasonality of floods. Analysis method appropriately treat the timing (date) of floods as a circular random variable, and determine the relative timing of peak streamflows based on computed probability density of circle (representing a calendar year). Resampling methods are used to assess the random fluctuations (for the given sample sizes) from historical data, and serve a baseline to isolate primary modes of flood seasonality.



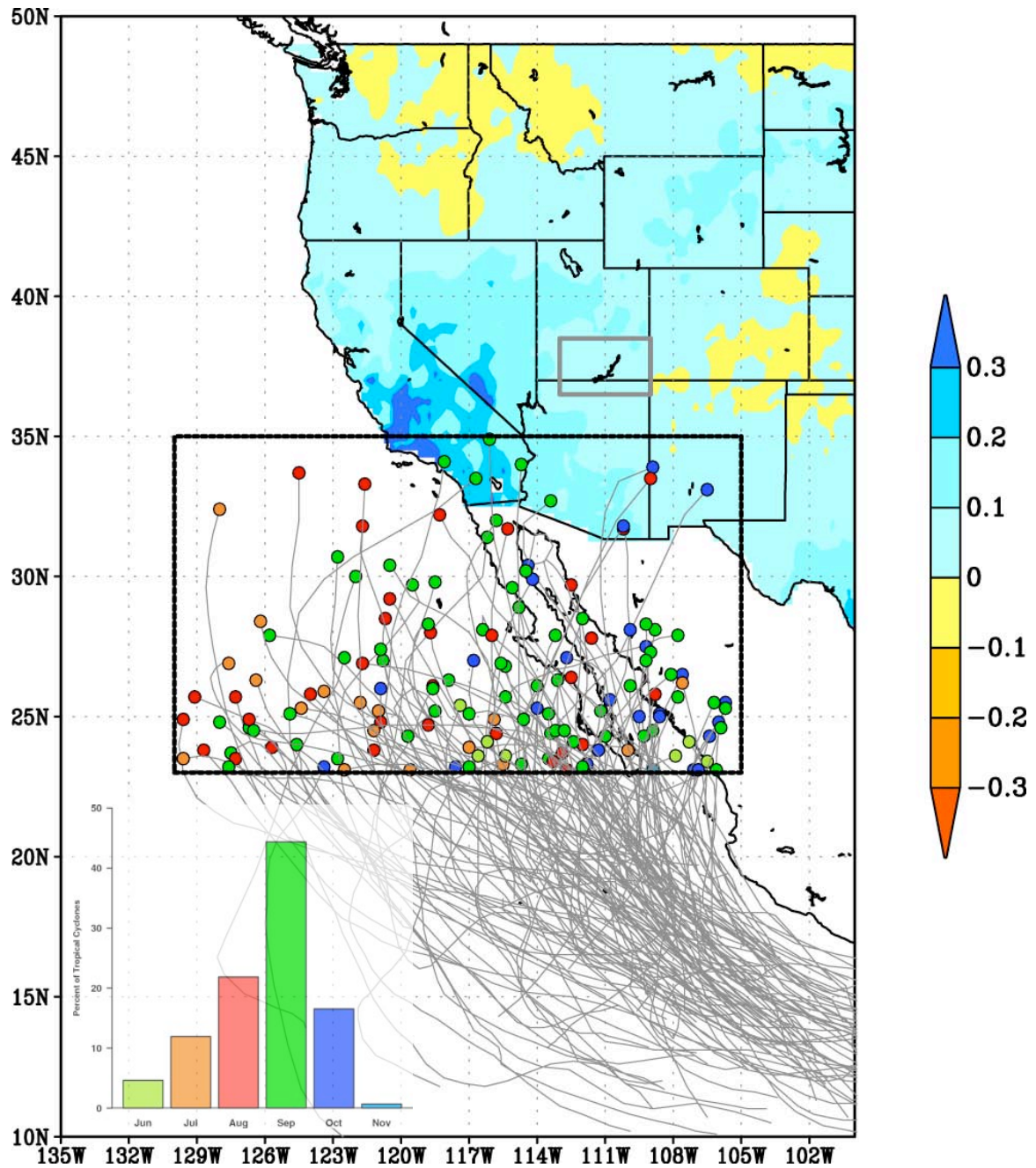
**Figure 1.** Streams classified based on the seasonality of the statistics of the timing of floods (3-day discharge peaks) for streams in the western US. Empirical probability density for the seasonality of floods (right) shows the principal modes of flood peaks for the western US region: Cold season peaks (December-March, coded as **C**), Spring-Summer peaks (April-July, coded as **S**), and Warm season peaks (August-November, coded as **W**).

Delineated streams highlight the spatial scales at which coherent flood seasonality occurs, in turn allowing a focused analysis of large-scale climatic influences. For the southwest region, select streamgauges show bimodal seasonality, reflecting both the role of winter and warm climatic variations. Ongoing work focuses on diagnosing the large-scale climatic precursors that may influence the seasonal streamflow volumes, peak flows, and the statistics of flood peaks within a season. Primary focus is on the warm season climate and associated southwestern floods and their impact for the Grand Canyon region. A goal of this work is to develop a season-ahead precipitation and streamflow forecasting methodology to be tested for the Grand Canyon region.

## 2. *The role and contribution of tropical cyclone related precipitation during the warm season*

Landfalling and dissipating tropical cyclones emanating from the North-East Pacific basin contribute to the moisture and rainfall in the Southwest during the

June to November period. A key focus of ongoing research is to understand the extent to which episodic flooding from heavy precipitation events in the Southwest is contributed by the tropical cyclones. Furthermore, the climatic controls on the frequency, trajectory, and timing of tropical cyclones are also of interest for management concerns within the Grand Canyon. An analysis of the 1948-2004 hurricane track data from the NOAA Coastal Services allowed selection of 151 candidate dissipating events within the proximity of the southwest that provide moisture for potential precipitation and flooding events. Analysis of composite precipitation within a 7-day window centered around the date of cyclone dissipation revealed a precipitation *pulse*. Figure 2 shows the composite standardized departures in precipitation for the entire western United States for the 151 events shown by colored dots. The relative frequency of cyclones within the June-November season (Figure 2, inset) shows that, climatologically, September accounts for the majority of tropical cyclones. Further analysis of the Paria River peak flow and sediment data shows that 56 out of the 151 cases (shown in Figure 2) are associated with flood events exceeding one standard deviation in magnitude. This emphasizes the import of tropical cyclone driven moisture and flood potential on Paria River. Analysis of tropical sea surface temperature during Spring shows its lead relationships with the July-September SSTs in the East Pacific cyclone-genesis region. Further analysis of the historical data, and accounting for subjectivity in discerning the tropical cyclone related moisture are a focus of ongoing work. Furthermore, season-ahead outlooks of tropical cyclone activity, role of the large-scale environment, and impacts for Paria floods and sediment transport are also being investigated.



**Figure 2.** Standardized anomaly composite precipitation for the 151 cases of dissipating or landfalling cyclones in the proximity of the southwestern United States. The tracks of the individual cyclones are shown in gray. The colored dots show the location where the storm dissipated. The barplot (inset) highlights the month-by-month relative frequency of the 151 selected cases; the colored dots on the storm tracks correspond to colors (and months) in the barplot.

## **Conference Presentations**

Jain, S. and P. D. Sardeshmukh, The impact of climate forecast uncertainty on water resources operations and management. NOAA Climate Prediction Applications Science Workshop. Columbia University, New York, March 15-17, 2005.

Jain, S., R. S. Pulwarty, J. Eischeid, T. S. Melis, and D. J. Topping, Warm season storms, floods, and sediment inputs into the Grand Canyon: Applications to decision making and adaptive management. Presented at the Joint Session on The Earth Information System for Water Decision Making, 85<sup>th</sup> Annual Meeting of the American Meteorological Society, San Diego, California, January 9–13, 2005.

Jain, S., R. S. Pulwarty, J. Eischeid, T. S. Melis, and D. J. Topping, Climate-related flood and sediment transport from the Paria River to Grand Canyon: The role of multiple time scales. Session on Managed Rivers as Large-Scale Experiments in Geomorphic Processes. AGU Fall Meeting, San Francisco, December 2004.